PHYTOTOXICOLOGY 1995 INVESTIGATION:

ATLAS SPECIALTY STEELS

WELLAND

SEPTEMBER 1998

Ontario

Ministry
of the
Environment

ISBN 0-7778-7885-2

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Cette publication technique
n'est disponible qu'en anglais.

PIBS 3686E

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Report No: SDB-014-3511-1997

BACKGROUND:

Altas Specialty Steels is a major industrial operation in Welland, Ontario. It is located on a large property in the north-central part of the city. The Atlas industrial buildings are aligned along the Canadian National Railway line on the east side of the Welland River, and extend for a distance of about 1.5 kilometres. This company (or its corporate predecessor) was established at this location in 1928.

Atlas produces specialty grade steels by alloying steel with other metals. The primary raw material used by this company is steel scrap. The scrap is melted in an electric arc furnace located at the extreme north end of the complex. The alloying metals are added to the melt and the products are cast, rolled or forged to the desired dimensions.

Detailed information about the nature and quantities of alloying materials used by Atlas was not researched for this investigation. However, based on information regarding the types of alloys produced by Atlas, the nature of these metals can be inferred. For example, stainless steel involves alloying steel with substantial proportions of chromium and nickel. High speed and tool steel can contain chromium, vanadium, manganese, molybdenum, and tungsten.

INVESTIGATION AREA:

Atlas Specialty Steels is located in an area of Welland containing a mix of residential, commercial, and industrial properties. There are at least four smaller metal fabricating industries east of Atlas, and GenCorp Automotive, a rubber products manufacturer, is located immediately west of Atlas. Residential properties are located to the west and south of these industrial properties. Figure 1 reflects the locations of the various industries with respect to each other and the residential areas.

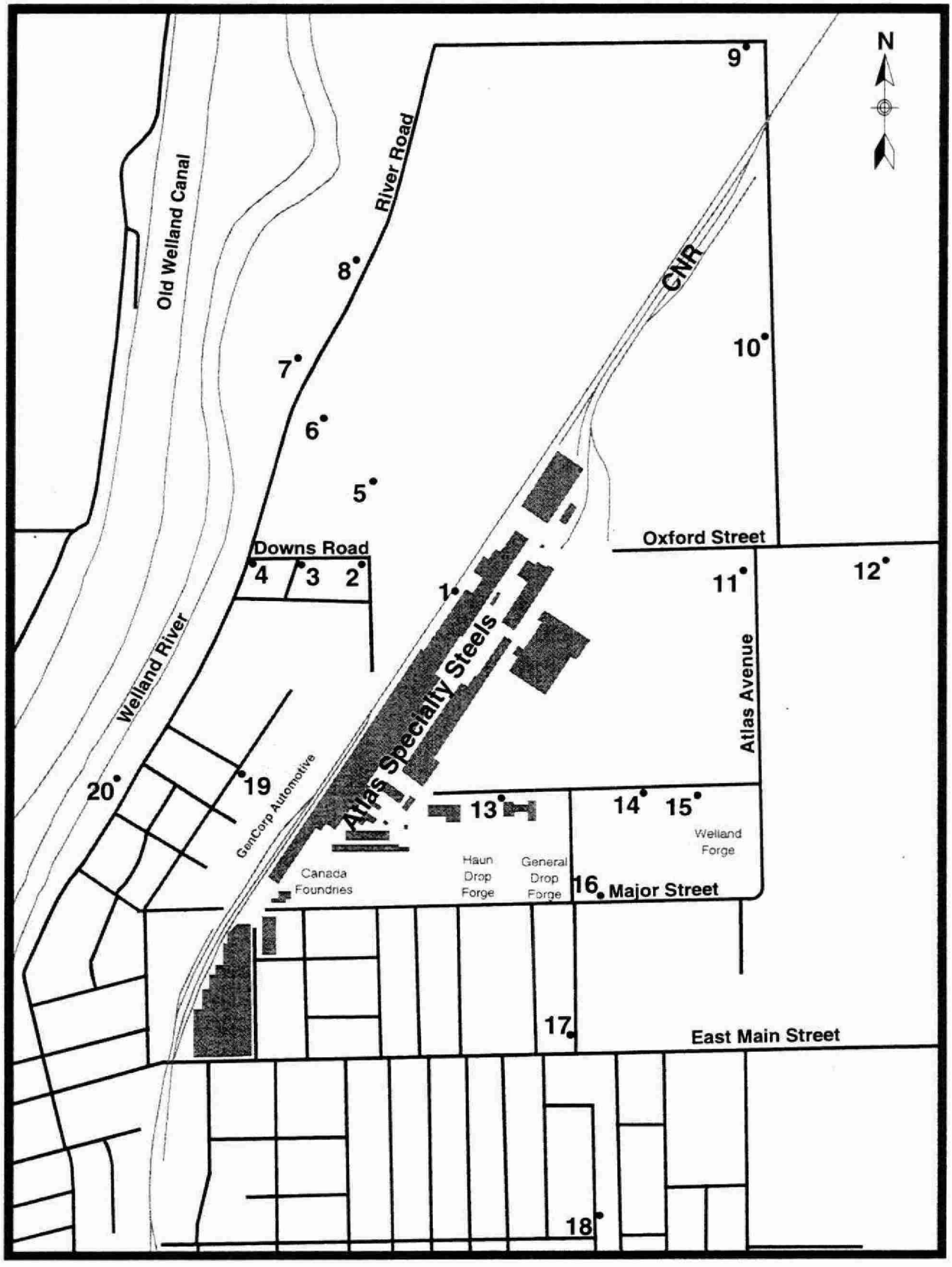
PREVIOUS INVESTIGATIONS:

The Phytotoxicology Section first investigated the effects of air emissions from this company in the early 1970s. The concern at that time was fluoride releases from the furnace which used fluorspar as a fluxing agent. Elevated concentrations of fluoride were detected in tree foliage but foliar injury ascribable to fluoride was not detected.

The Phytotoxicology Section returned in 1993 to investigate the effect of Atlas metal emissions on soil. The investigation consisted of a collection of soil samples from eight locations and analysing for various metal elements. Elevated concentrations of nickel, chromium and molybdenum were identified at locations close to the Atlas complex.

In 1994, the Phytotoxicology Section conducted an investigation focussed on air emissions from GenCorp Automotive. Soil samples collected during that investigation were analysed for metals as part of a routine exploratory investigation and were found to contain elevated concentrations of nickel, chromium and molybdenum, and to a lesser extent, cadmium and zinc. Since the GenCorp processes do not include these elements, the elevated soil concentrations were ascribed to Atlas or the other metal fabricators.

Figure 1: Maple Foliage Sampling Locations in Vicinity of Atlas Specialty Steels, Welland



INVESTIGATION OBJECTIVES AND PROCEDURES:

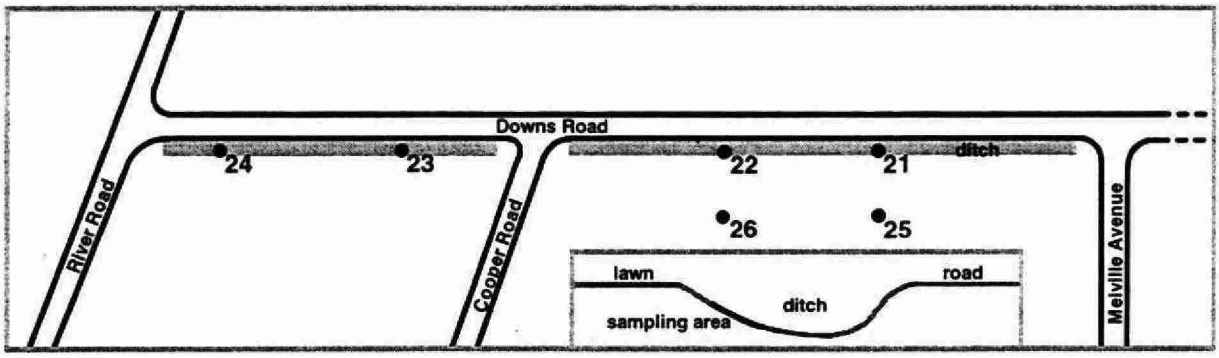
There were two objectives defined for this investigation during a meeting between Phytotoxicology and Niagara District staff. The first was to determine the current nature and spacial extent of metal emission impacts from the Atlas operation by utilizing tree foliage as a biological indicator of such emissions. The second was to assess the possibility that accumulated metal contaminants in the soil could be entering the Welland River via surface runoff.

This investigation took place on October 3, 1995. To fulfill the first objective, the area around Atlas was surveyed to identify potential sampling locations (i.e. a common species of tree that could be sampled). Twenty sampling locations were identified. These were distributed, as indicated in Figure 1, on all sides of the Atlas complex. Most of these locations contained a silver maple tree, although in some cases, sugar or Norway maples were accepted as substitutes to improve the areal coverage of this investigation.

Sampling consisted of using a pruning pole to cut one or two branches from the side of the canopy facing the Atlas complex, removing the leaves, and placing them into labelled polyethylene bags. Duplicate samples were collected at each location.

The soil sampling to meet the second objective was conducted along the south side of Downs Road. A roadside ditch extends along the entire length of Downs Road. Surface drainage from the residential properties would use this ditch as a path to the Welland River. Figure 2 details the soil sampling locations. Four of these locations were within the sloping wall of the ditch, as indicated in the insert in the figure. Two locations were established on the residential lawns along Downs Road, about 20 metres from the road.

Figure 2: Surface Soil Sampling Locations in Vicinity of Atlas Specialty Steels, Welland



Soil samples were collected with an Oakfield™ soil corer. This device removes a two-centimetre diameter core when inserted into the soil. In this investigation, the top five centimetres of soil was collected. At each sampling location, about 12 such cores, constituting one sample, were collected and placed into a labelled polyethylene bag. Duplicate samples were collected at each location.

All samples were forwarded to the Phytotoxicology processing laboratory where they were dried, ground and placed into glass jars. They were then delivered to the MOEE Laboratory Services Branch analytical laboratory for analysis of a range of crustal elements and trace metals.

RESULTS:

The results of the chemical analyses of the maple foliage samples, as means of the duplicate samples, are reported in Table 1. Cobalt, vanadium, arsenic, selenium and antimony were also determined but are not reported because the majority of the concentrations were below analytical detection limits.

Table 1: Concentrations (μg/g) of Crustal and Metal Elements in Maple Foliage in the Vicinity of Atlas Specialty Steels, Welland

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	ULN
Al	67	105	65	65	64	92	60	39	95	101	500
Ba	4.9	15.5	14.0	19.0	6.6	5.7	4.8	5.9	5.3	7.2	
B	27	55	45	51	24	39	39	61	30	29	175
Ca	10250	16500	16500	23000	6300	12000	11000	16500	9000	9000	
Cd	0.4	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.4	2
Cu	14	5	8	6	5	10	9	7	5	13	20
Cr	**9.6**	**10.3**	4.0	2.6	7.5	3.9	2.2	3.2	3.5	**16.0**	8
Fe	350	395	205	195	285	315	220	175	275	695	1000
Mg	3400	2000	2700	1850	2150	3250	2600	3500	3600	4050	7000
Mn	**160**	**265**	46	42.5	**230**	**265**	**210**	92	55.5	**230**	100
Mo	**3.9**	**3.2**	1.3	**1.6**	**2.1**	**1.7**	1.0	1.1	1.2	**6.6**	1.5
Ni	**12.5**	**9.2**	3.8	2.1	**8.3**	5.5	2.7	3.5	3.1	**16.0**	7
Pb	2.9	2.7	1.6	1.2	1.9	2.3	1.4	1.3	2.9	10.4	60.0
Sr	46	52	55	62	22	41	57	106	37	30	
Zn	40	21	34	24	38	40	52	61	26	80	250

	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20	ULN
Al	61	44	83	86	150	88	58	86	61	54	500
Ba	8.5	4.9	11.0	4.9	9.6	8.6	10.5	7.2	7.8	21.0	
B	58	36	52	75	40	36	46	32	34	56	175
Ca	12000	11000	15000	8400	15500	15500	17000	11500	15000	15500	
Cd	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.2	0.2	0.1	2
Cu	7	3	10	5	10	11	7	5	14	3	20
Cr	3.5	2.3	14.5	6.2	**9.0**	5.4	2.1	2.0	**16.5**	3.8	8
Fe	290	230	675	450	**1255**	360	195	245	505	210	1000
Mg	2550	3650	4450	6000	4400	3100	2700	4450	2200	2000	7000
Mn	**155**	**120**	44	27	32	80.5	79.5	145	38.5	91.5	100
Mo	1.0	0.9	**3.9**	**5.0**	**2.2**	1.5	0.6	0.4	**5.7**	**2.2**	1.5
Ni	3.1	1.8	**13.0**	4.7	6.0	4.4	1.9	1.8	**16.0**	3.2	7
Pb	0.8	0.8	2.7	0.5	1.5	1.3	1.1	1.3	0.5	0.5	60.0
Sr	40	57	111	29	120	49	55	74	53	150	
Zn	56	30	35	19	25	37	38	41	34	11	250

ULN = Phytotoxicology Upper Limit of Normal guidelines for urban tree foliage. Shaded data exceed guideline. (see Appendix 1)

Also reported in Table 1 are the Upper Limit of Normal (ULN) guideline concentrations (see Appendix 1) for urban tree foliage. Shaded and bolded data indicate exceedence of the guideline.

Table 2 contains the results of the chemical analyses of the soil samples, also as means of the duplicate samples. The OTR guideline (see Appendix 2) concentrations for old urban parkland soil are also listed and exceedences are shaded and bolded.

Table 2: Concentrations (μg/g) of Crustal and Metal Elements in Soil in Vicinity of Atlas Specialty Steels, Welland

	Site 21	Site 22	Site 23	Site 24	Site 25	Site 26	OTR_{98}
Al	13000	16000	18000	7750	**32000**	19000	27000
Be	0.5	0.6	0.8	0.5	**1.2**	0.7	0.97
Ba	68	75	115	71	140	92	180
Ca	8100	6500	12500	33500	6050	3700	58000
Cd	0.25	0.40	0.45	0.45	**1.5**	**0.95**	0.84
Co	6.9	8.6	11	4.9	14	10	17
Cu	17	18	25	30	36	26	65
Cr	20	31	31	17	**180**	**110**	62
Fe	18000	19500	27000	14000	30000	23000	33000
Mg	3950	4250	6850	4650	6100	4500	16000
Mn	495	635	665	560	990	555	1300
Mo	0.95	1.7	0.85	1.2	**16**	**9.1**	0.85
Ni	21	29	31	15	**160**	**104**	32
Pb	15	16	10	8	58	49	98
Sr	25	21	36	64	35	20	78
V	29	33	37	20	52	40	71
Zn	58	74	69	52	**260**	**155**	140
As	3.8	4.7	5.8	3.1	8.7	8.5	17
Se	0.40	0.45	0.25	0.25	1.0	0.65	1.3
Sb	0.30	0.25	0.20	0.20	**0.70**	**0.50**	0.43

OTR_{98} = Ontario Typical Range guidelines for old urban parkland soil. Shaded data exceed guideline. (see Appendix 2)

DISCUSSION:

The ULN guideline concentrations for tree foliage were exceeded at many of the sampling locations. These exceedences were restricted to five different elements, namely chromium, manganese, molybdenum, nickel, and iron. All of these metals are involved in the manufacter of specialty steels as discussed in the Background section of this report. This observation indicates that air borne material containing these metals is present within the investigation area.

The degree to which foliar concentrations exceeded the ULN guidelines ranged from marginal to factors of two or three. Of the twenty sampling locations, fourteen had at least one element whose concentration exceeded a ULN guideline. Locations where the ULN guidelines were not exceeded tended to be locations that were farther removed from the Atlas complex. These included Sites 8, 9, 17 and 18. Locations where the ULN guidelines for three or four of the elements were exceeded tended to be close to the Atlas complex. These included Sites 1, 2, 5 and 19. Exceptions to these generalizations were also present. For example, Site 10 with exceedences for four elements was not any closer to Atlas than Site 3 which had no exceedences.

These observations suggest that emissions from Atlas Specialty Steels have had a measurable impact on neighbouring properties. The geographic extent of these impacts cannot be explicitly defined, however it can be stated that Atlas emissions have resulted in elevated concentrations of metals in tree foliage within about 500 metres from the Atlas complex.

The soil sampling component of this investigation also identified elevated concentrations of chromium, molybdenum and nickel, which were also identified as elevated in tree foliage. In addition, aluminum, beryllium, cadmium, zinc and antimony also exceed the OTR_{98} guidelines for old urban parkland soil. Almost all of these exceedences occurred at Sites 25 and 26, which were located on the residential lawns of properties on the south side of Downs Road.

With the exception of molybdenum, the OTR_{98} guidelines were not exceed at the four locations (Sites 21 through 24) within the roadside ditch. Since the physical separation between the ditch and lawn locations was as short as 20 metres, it appears that the soil at one of the two areas has been subjected to recent disturbance.

The most probable explanation for this discrepancy in soil metal concentrations is that the soil within the ditch profile (Sites 21-24) has not been exposed to Atlas metal emissions and deposition for very long. This might mean that the soil was placed there in a recent road or drainage construction project. The lead concentrations at these four locations support this hypothesis. Lead concentrations ranging from 8 to 16 micrograms per gram are typically associated with soil from remote, rural locations. The soil in the ditches has not been exposed to lead deposition that was commonly experienced during the tenure of leaded gasoline use.

While it appears that metal loading to the Welland River will not be enhanced by runnoff through this ditch system, this does not preclude loading through runoff through other pathways. This investigation identified soil contamination by metals associated with the Atlas operation, as did other Phytotoxicology investigations in this area, mentioned earlier in this report. Given the fact that surface soil is contaminated, any location subject to erosion could contribute to the metal load of the Welland River.

CONCLUSIONS:

This investigation demonstrated that current metal emissions from the Atlas complex resulted in elevated concentrations of these metals in tree foliage. The extent of this measurable affect was limited to a distance of about 500 metres from the complex. Accumulation of these metals in surface soil was demonstrated in this investigation and other Phytotoxicology investigations in this area.

APPENDIX 1

Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures. Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations
that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.

For more information on these guidelines please refer to *Ontario Ministry of the Environment "Upper Limit of Noraml" Contaminant Guidelines for Phytotoxicology Samples. MOE Report No.: ARB-138-88-Phyto, ISBN 0-7729-5143-8.*

APPENDIX 2

Derivation and Significance of the MOEE "Ontario Typical Range" Soil Guidelines

The MOEE "Ontario Typical Range" (OTR) guidelines are being developed to assist in interpreting analytical data and evaluating source-related impacts on the terrestrial environment. The OTRs are used to determine if the level of a chemical parameter in soil, plants, moss bags, or snow is significantly greater than the normal background range. An exceedence of the OTR_{98} (*the OTR_{98} is the actual guideline number*) may indicate the presence of a potential point source of contamination.

The OTR_{98} represents the expected range of concentrations of chemical parameters in surface soil, plants, moss bags, and snow from areas in Ontario not subjected to the influence of known point sources of pollution. The OTR_{98} represents 97.5 percent of the data in the OTR distribution. This is equivalent to the mean plus two standard deviations, which is similar to the previous MOEE "Upper Limit of Normal" (ULN) guidelines. In other words, 98 out of every 100 background samples should be lower than the OTR_{98}.

The OTR_{98} may vary between land use categories even in the absence of a point source of pollution because of natural variation and the amount and type of human activity, both past and present. Therefore, OTRs are being developed for several land use categories. The three main land use categories are Rural, New Urban, and Old Urban. Urban is defined as an area that has municipal water and sewage services. Old Urban is any area that has been developed as an urban area for more than 40 years. Rural is all other areas. These major land use categories are further broken into three subcategories; Parkland (which includes greenbelts and woodlands), Residential, and Industrial (which includes heavy industry, commercial properties such as malls, and transportation rights-of-way). Rural also includes an Agricultural category.

The OTR guidelines apply only to samples collected using standard MOEE sampling, sample preparation, and analytical protocols. Because the background data were collected in Ontario, the OTRs represent Ontario environmental conditions.

The OTRs are not the only means by which results are interpreted. Data interpretation should involve reviewing results from control samples, examining all the survey data for evidence of a pattern of contamination relative to the suspected source, and where available, comparison with effects-based guidelines. The OTRs are particularly useful where there is uncertainty regarding local background concentrations and/or insufficient samples were collected to determine a contamination gradient. OTRs are also used to determine where in the anticipated range a result falls. This can identify a potential concern even when a result falls within the guideline. For example, if all of the results from a survey are close to the OTR_{98} this could indicate that the local environment has been contaminated above the *anticipated average,* and therefore the pollution source should be more closely monitored.

The OTRs identify a range of chemical parameters resulting from natural variation and normal human activity. ***As a result, it must be stressed that values falling within a specific OTR_{98} should not be considered as acceptable or desirable levels; nor does the OTR_{98} imply toxicity to plants, animals or humans.*** Rather, the OTR_{98} is a level which, if exceeded, prompts further investigation on a case by case basis to determine the significance, if any, of the above normal concentration. Incidental, isolated or spurious exceedences of an OTR_{98} do not necessarily indicate a need for regulatory or abatement activity. However, repeated and/or extensive exceedences of an OTR_{98} that appears to be related to a potential pollution source does indicate the need for a thorough evaluation of the regulatory or abatement program.

The OTR_{98} supersedes the Phytotoxicology ULN guideline. The OTR program is on-going. The number of OTRs will be continuously updated as sampling is completed for the various land use categories and sample types. For more information on these guidelines please refer to *Ontario Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags, and Snow. MOEE Report No.: HCB-151-3512-93, PIBs No.: 2792, ISBN 0-778-1979-1.*

Date Due
